Scaling Analysis of Author-Level Bibliometric Indicators

Wildgaard, Lorna Elizabeth; Larsen, Birger

Publication date:
2014

STI 2014 Leiden

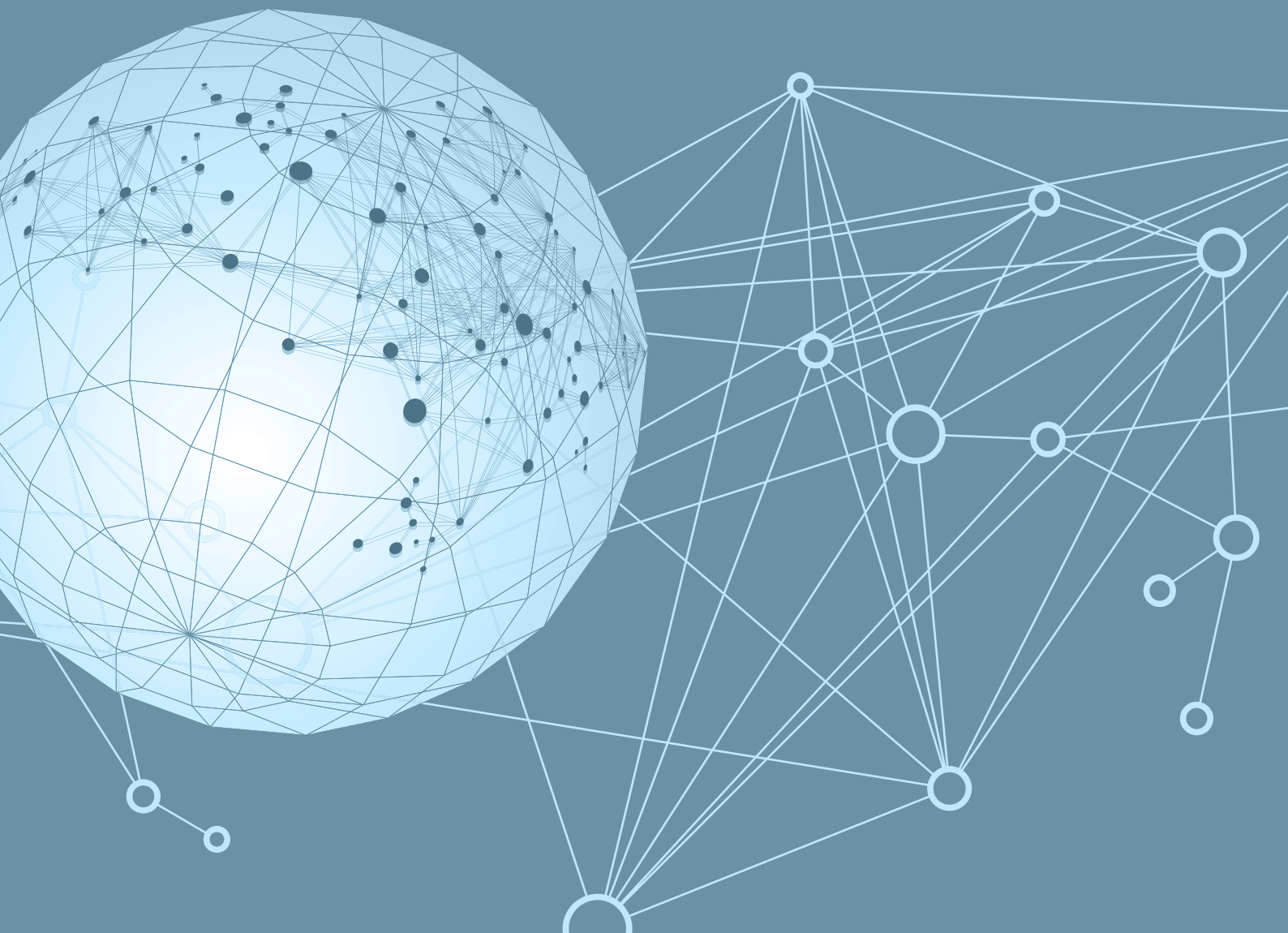
Proceedings of the science and technology indicators conference 2014 Leiden

"Context Counts: Pathways to Master Big and Little Data"

3 - 5 September 2014 in Leiden, the Netherlands

Electronic version - Edited by Ed Noyons

Published by Universiteit Leiden - CWTS 2014



Scaling Analysis of Author Level Bibliometric Indicators[1]

Lorna Wildgaard* and Birger Larsen**

*pnm664@iva.ku.dk
Royal School of Library and Information Science, Birketinget 6, 2300 Copenhagen (Denmark)

** birger@hum.aau.dk
Department of Communication and Psychology, Aalborg University Copenhagen, A. C. Meyers Vænge 15, 2450 Copenhagen SV (Denmark)

Introduction

Despite of the concerns from the bibliometric community, evaluation of the individual through bibliometric indices is already performed as a form of 'pseudo peer review' in selection of candidates for tenure, in background checks of potential employees' publication- and citation impact, and in appraisal of funding applications. As part of developing the ACUMEN portfolio we therefore undertook an extensive review of 114 bibliometric indicators in Wildgaard, Schneider and Larsen (2014) to identify 1) which author level indices are useful to document the effect of publication performance, 2) identify which scientific activities it is possible to measure and with which indices, 3) analyse the applicability of these indices by discussing the strengths and weakness of each one, and 4) identify if there is a need for any additional novel indicators to measures the performance of individuals. The review confirmed that there is no immediate need to develop new bibliometric indicators. There is a wealth of indicators to choose from, some used in practice and some theoretical only. There is however a need to understand the usefulness of existing indicators and which ones represent independent research activities of authors.

We have begun our investigation into how indicators complement each other, specifically if there is a redundancy among indicators, i.e. two or more indicators measure the same thing, and which indicators are the "best" choice in regards to four predefined disciplines. The main parameter we judge the usefulness of indicators is on their simplicity, understood as the simplicity of data collection and the simplicity of mathematical computation for each indicator (Wildgaard, Schneider & Larsen 2014). The present study is a further investigation into which effects of publishing and citing these simple indicators attempt to capture.

Data

The data is drawn from a set of 2,554 European researchers in four scientific disciplines, *Astronomy*, *Environmental Science*, *Philosophy* and *Public Health*, identified in an online survey of web-presence conducted by Wolverhampton University in 2011. In the survey, the respondents reported their academic discipline and seniority, and these are used to group the researchers in our study. We found 741/2,554 researchers had a curriculum vitae and a publication list on the web. We extracted their publications from the CVs/publication lists and searched the Thomsen Reuters Web of Science (WoS) to identify them. We identified 34,660 citable papers. Additional publication and citation information on articles and reviews in this

[1] This work was supported by the ACUMEN FP7 project. The work presented here is used in the development of Guidelines for Good Evaluation Practice. The ACUMEN collaboration aims at understanding how researchers are evaluated and the science system can be improved and enhanced, www.research-acumen.eu

data set was kindly provided by the Centre for Science and Technology Studies (CWTS) at Leiden University, the Netherlands from their custom version of the WoS. As the CWTS data does not contain data from the Conference Proceedings Citation Indexes we do not have additional data on 3,693 citable papers and these are excluded from the present analysis. Our final data set thus consists of 30,967 publications with additional citation information, Table 1. The table shows the mean and median number of publications and citations, mean number of citations per year and also the meanPage which is an indicator of the mean academic age of the researchers, measured as the number of years since the researcher's first publication registered in WoS. Confidence intervals (CI) are computed to contextualize these averages.

Methods

Bibliometric indicators were derived from a review of the literature (Wildgaard, Schneider & Larsen 2014).

The simplicity of data-collection and calculation of each indicator was assessed, and only indicators that we deemed practically feasible for individual researchers without special bibliometric expertise or access to special datasets are included in the present analysis. This results in 37 potentially useful indicators at the individual level. All these indicators are simple to calculate but in prioritizing simplicity our method may result in choosing coarse measures of performance. These indicators are supplemented by 17 more fine-grained field level performance indicators supplied by CWTS. For an overview, see the Appendix where the indicators are briefly presented.

The set of selected indicators is intended to capture the major output and effects of a researcher's published work, defined as: *publication output*, i.e. counting publications in various ways; *the effect of output* i.e. raw citation or fractionalised counts, as well as average citations of the entire portfolio; *impact over time*, e.g. with citations adjusted for length of academic career and field norms, and finally *citations to core or selected publications*.

Preliminary analyses

IBM SPSS version 19 was used for calculation of statistics.

Table 13. Sample of 741 researchers, distribution of publications and citations across disciplines and seniorities.

	Publications					Citations			
Discipline	**Sample**	**Range**	**Median (CI)**	**Mean (CI)**	**MeanPage (CI)**	**Range**	**Median**	**Mean (CI)**	**MeanCPY**
	***Astronomy*, 192 researchers**								
PhD	15	2-36	7(5.0;14.2)	10.8(5.6;15.9)	4.8(3.9;5.7)	8-529	150(27.9;209.7)	149.4 (64;234.7)	36.8(12.8;60.7)
Post Doc	48	3-103	19.5(14;26.5)	26 (19.9;32.1)	8.8(7.9;9.6)	3-3177	201.5(140.4;479.4)	561.1(339,7;782.4)	61.4(36.9;85.8)
Assis Prof	26	10-142	39.5(30;65.9)	51 (37.3;64.8)	12.2(10.6;13.7)	69-4009	702 (432.2;1327.5)	1118,6 (675;1562.1)	84(58.5;109.4)
Assoc Prof	66	7-292	61.5(48.5;75.4)	77.7(63.2;92.2)	19.7(18.1;21.2)	19-9083	1214(783.6;1622.8)	1981.1(1477.8;2484.4)	107(79.9;134.0)
Professor	37	34-327	90(75.2;109.6)	121.3(92.8;149.8)	25.7(23.4;27.9)	177-16481	1889(1292.9;3245.3)	3579.1(2170.9;4988.2)	146(97.5;194.4)
	***Environmental Science*, 195 researchers**								
PhD,	3	3-5	4	4	9.6	16-60	34	36	5.6
Post Doc	17	2-59	9(6;12.9)	12.8(5.6;20)	6.8(4.5;9.0)	10-642	41(25;56)	91.7(11.1;172.2)	10.6(5.8;15.3)
Assis Prof	39	2-46	18(13.9;20)	19(15.6;22.5)	10.7(8.8;12.5)	0-573	148(90.6;167.6)	185.4(133.7;237.1)	16.7(12.5;20.8)
Assoc Prof	85	1-103	29(25;41)	36.8(31.7;42)	16.6(15.2;18)	2-2519	326(232.9;459.4)	520.1(404.4;635.7)	30.2(23.9;36.4)
Professor	51	1-425	51.5(39.3;64.2)	59.7(46.8;72.5)	24.1(21.8;26.3)	6-14141	435(324.5;722.6)	998.1(614.7;1381.5)	48.2(29.8;66.5)
	***Philosophy*, 222 researchers**								
PhD	8	1-5	1(1;4.1)	2(0.6;3.3)	3.5(2.3;4.6)	1-33	0.5(0;13.5)	6.2(-3.2;15.7)	1.7(-0.31;3-71)
Post Doc	22	1-31	4(3;8)	7(3.8;10.1)	6.2(4.8;7.5)	0-235	8(1-10)	21.4(-1.9;44.7)	15.4(2.0;28.7)
Assis Prof	44	1-106	6.5(4;8.9)	10.8(5.7;15.9)	7.6(6.3;8.9)	0-1829	6.5(3;20)	74.3(-11.5;160.2)	6.5(0.6;12.3)
Assoc Prof	73	1-45	7(6;9)	10(7.8;12.1)	11.2(9.6;12.7)	0-565	8(5;13)	50.7(22.7;78.7)	4.2(1.9;6.4)
Professor	75	1-140	18(13.5;23.4)	28.1(21;35.2)	19.6(17.6;21.5)	0-3495	29(20.5;65.6)	157(52.1;262)	7.0(2.6;11.3)
	***Public Health*, 132 researchers**								
PhD	9	4-27	8(7.1;17.8)	12.2(6.6;17.8)	5.6(3.7;7.4)	7-253	60(34.5;146.7)	82.2(23.5;140.8)	17.8(4.5;31.0)
Post Doc	14	1-23	11(8.8;14.4)	12(8.6;15.3)	7.2(4.9;9.4)	0-353	80.5(21.5;203.9)	113.6(49.4;177.6)	14.1(7.9;20.2)
Assis Prof	30	3-288	22(13.1;29.6)	36.2(15.6;56.7)	10.7(8.5;12.8)	10-3796	167(107.8;350.8)	417.4(131.4;703.3)	34.4(17.8;50.9)
Assoc Prof	50	4-221	43(30.6;56.3)	54.6(41.6;67.7)	16(14.2;18.5)	4-3649	518(312.6;701.7)	778.5(539.4;1017.5)	46.7(33.6;59.7)
Professor	29	5-661	76(53.6;107.6)	110.2(62.7;157.7)	17.4(14.7;20.0)	13-13520	954(554,2;2394.7)	2104(1065.3;3142.6)	109.8(62.1;157.4)

Predicting the usefulness of indicators at the seniority level
In order to investigate the usefulness of indicators for different levels of academic seniority we computed a cross-correlation matrix (per discipline) for the indicators using Kendall's tau rank correlation coefficient, and *gamma* as the symmetric measure of association. Across all four disciplines the association between seniority and the h-type indicators was minimal or none existent. This lack of association makes sense, as h-type indicators are dependent on citations and publications also having specific seniority level values, and clearly this is not the case as the range of publications and citations as well as the confidence intervals around the averages document, Table 1.

Identifying central and isolated indicators across disciplines
So far our analysis shows that publication and citation data between scholars within seniority is so varied that recommending any of our 52 sampled indicators as preferred "seniority level indicators" is unwise. We take the analysis up a level, from seniority to discipline, to investigate if the indicators are able to represent disciplinary traits. Inspired by Franceschet (2009) we begin by analysing if indicators display high correlations to other indicators, and identifying indicators that practically measure the same inherent properties. If indicators can be grouped by such an analysis into "clusters" of highly similar indicators, then the simpler alternatives from each cluster can be recommended over more complex ones.

Table 2 uses data from the correlation matrices to highlight central and isolated indicators. Isolated indicators are defined as having any only moderate or weak links, strength of association ≤ 0.7, to any of the other of the 51 indicators in the correlation. Central indicators are the indicators that have the highest number of links, over 0.7, to the other 51 indicators in the matrix (indicated in Table 2, column 4).

Table 14. Isolated and Central indicators across disciplines.

Discipline	Isolated Indicators	Central Indicators	Number of links to other indicators
Astronomy	App, sum sc, AWCR_pp, fp, %nc, average mjs mcs, min mjs mcs, maxs mjs mcs, average mnjs, h norm, wu	Hg IQP, AR	25 24
Environmental Science	Pyrs, App, %sc, Fp, nnc, %nc, Cage, AWCR_pp, PI, average mnjs, min mjs mcs, maxs mjs mcs, nproductivity adjusted papers, wu, AR	H, h2 popH, Q2, e, IQP	26 25
Philosophy	App, %sc, nnc, &nc, PI, sum pp top prop, average mjs mcs, max mjs mcs, average mnjs, nproductivity adjusted papers, hnorm, Wu	IQP AR, h2, Q2, e, g, h	28 27
Public Health	Pyrs, app, %sc, nnc, %nc, cage, AWCR_pp, minC, PI, min mjs mcs, average mnjs, nproductivity adjusted papers, hnorm, Wu	g Hg, ħ, h2	23 22

To investigate the role of the identified central and isolated indicators, we ranked researchers within disciplines and mapped how their position in the ranks changes when using these indicators as the control. We identified the top 10%, top 25%, middle 50% and bottom 25% in each set. We noticed that the isolated indicators produce a very random rank, placing a researcher sometimes in the top 10% and sometimes in the bottom 25%. The central indicators are all hybrid indicators. In *Astronomy* we used the **hg** index as the ranking factor, in *Environmental Science* the **h** index, in *Philosophy* the **IQP** index and in *Public Health* we used the **g** index. Across all disciplines we observed the same trend. If a researcher is placed in the top 10% of the sample by the central indicator, the researcher is placed in the top 10% using the other indicators that the central indicator has strong links to. Likewise, for researchers in the top 25%, middle 50% and bottom 25%.

To continue the analysis of how the central indicators gather other indicators around them we used the ALSCAL procedure in SPSS. This model allows us to visualize groupings of indicators as well as measure the distance between them. This is a good method of analysis of our skewed bibliometric dataset, as it accommodates interval and ratio scales, missing objects as well as symmetric and non-symmetric data. To get an idea of how well the model fits the data, we use the S-stress as a measure of fit ranging from 1 (worst possible fit) to 0 (perfect fit) and R-square to illustrate how much of the variance in the model is explained by these two dimensional models of Euclidean distance. The results present a low fit and high stress indicating that the maps are not very successful in capturing the complexity of higher dimensions and only coarsely group the indicators, Table 3 and Figures 1-4.

Table 3. MDS model fit

Discipline	Central Indicator	S-stress (R^2)	% variance explained (R^2)
Astronomy	hg	0.375	25
Environmental Science	H, h2	0.378	24
Philosophy	IQP	0.380	47
Public Health	g	0.499	38

Figures 1-4. Multidimensional Scaling maps of the studied bibliometric indicators in each of the four fields.

Fig.1. Astronomy

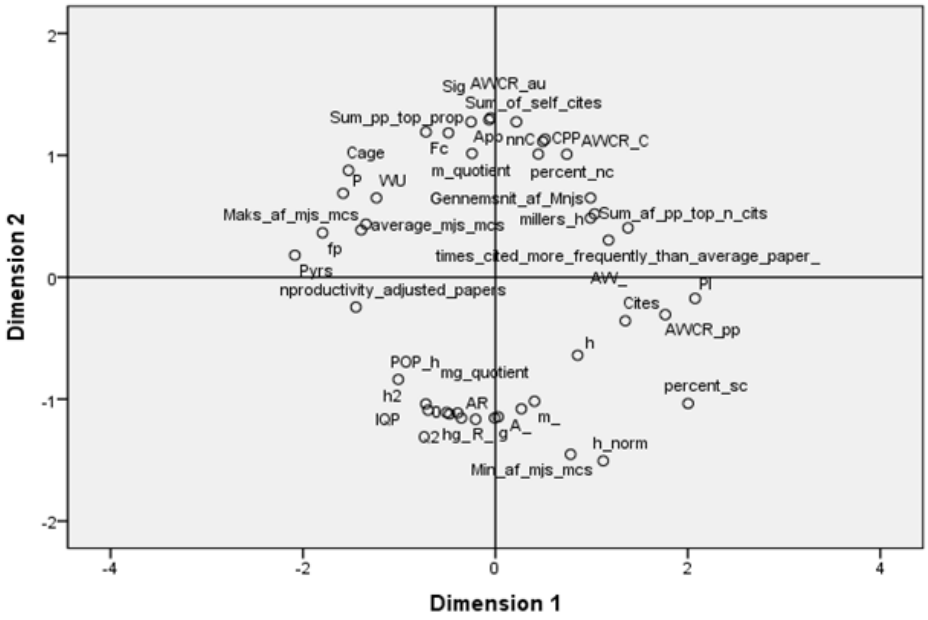


Fig. 2. Environmental Science

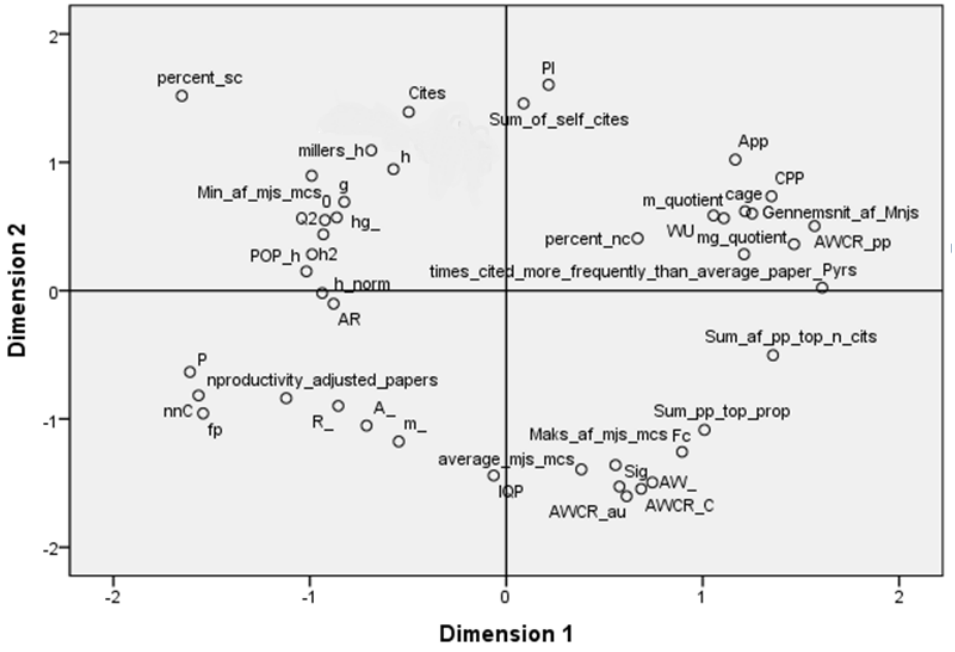


Fig. 3. Philosophy

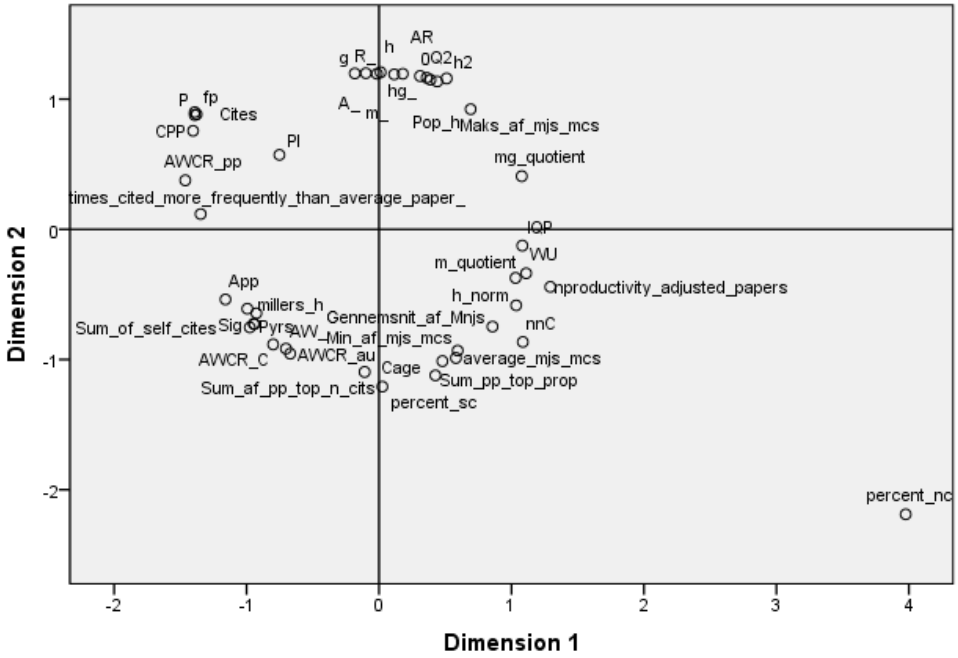
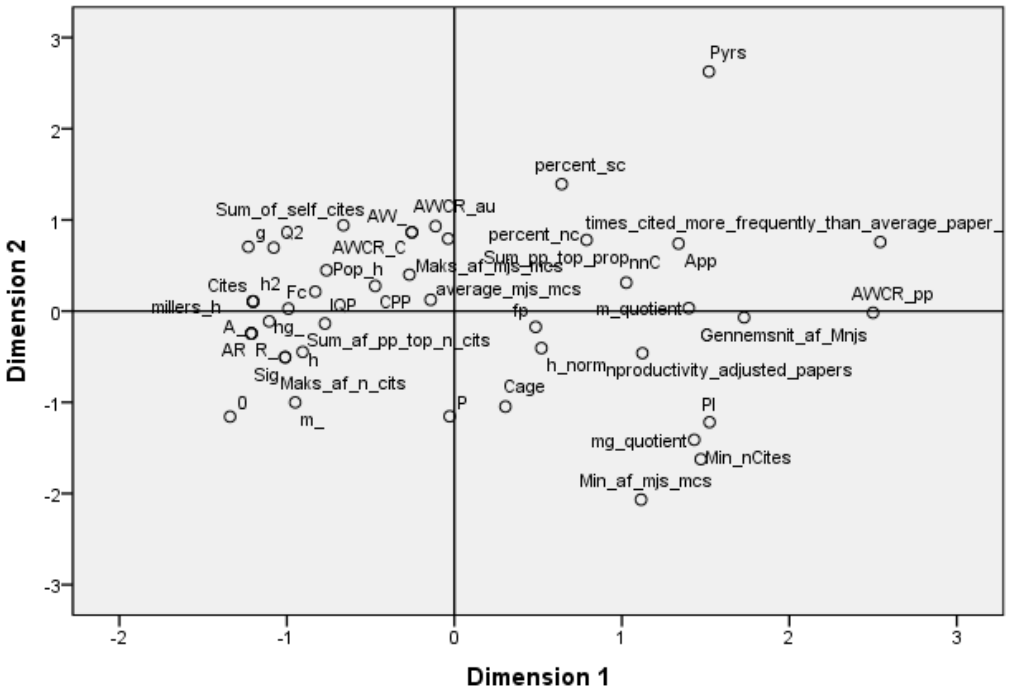


Fig. 4. Public Health



Next steps

The MDS maps show some overall structure, but the goodness of fit in the models is not high and needs improving. Across *Astronomy, Environmental Science and Philosophy* the indicators cluster in separate groups of hybrid, publication based or citation based (weighted or not weighted) indicators. In *Public Health* there are no clear groups. Depending on the

indicators in each group, research may be appropriately evaluated in a more nuanced way, and it is therefore interesting to continue this study. We plan to supplement the maps with a hierarchical clustering analysis, resulting e.g. in a dendrogram, that will allow us to trace backward or forward to any individual indicator or cluster at any level. In addition, this may give an idea of how great the distance is between indicators or groups that are clustered in a particular step. This will help us understand which aspects of the effect of a researchers' production the central and isolated indicators capture as well as the strength of the role of the indicator. Particularly 1) if the isolated indicators indicate activities not covered by the central indicators, and 2) if the overlap between the central indicators and the indicators they link to means they measure the same thing.

References

Wildgaard, L. Schneider, J.W & Larsen, B (2014) *Bibliometric Self-Evaluation: A review of the characteristics of 114 indicators of individual performance*. Manuscript submitted for publication and under revision

Franceschet, M (2009) A cluster analysis of scholar and journal bibliometric indicators. *Journal of the American* Society *for Information Science and Technology* 60(10). Pp.1950-1964

Appendix: Indicators of individual impact as well as discipline benchmarks analysed in this study.

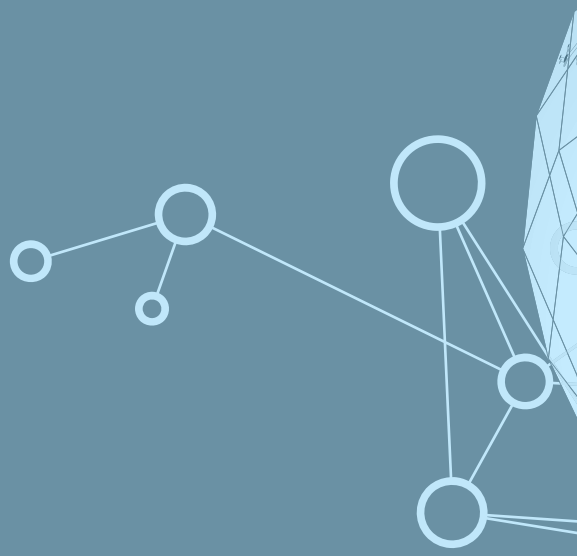
ID	Type	Abbr.	Indicator	Intention
Productivity metrics				
1	Publication	**P**	Publication count	Total count of production used in formal communication. Limited in our dataset to ISI processed publications
2	Publication	**Fp**	Fractionalized publication count	Each of the authors receive a score equal to 1/n to give less weight to collaborative works
3	Publication	**App**	Average papers per author	Average number of authors per paper over all publications
4	Publication/time	**Pyrs**	Years since first publication	Length of publication career from 1st article in dataset to 2013
Impact metrics				
5	Citation	**C**	Citation count	Use of all publications
6	Citation	**C-sc**	Citation count minus self-citations.	Use of publications, minus self-use.
7	Citation	**Sig**	Highest cited paper	Most significant paper
8	Citation	**minC**	Minimum citations	Minimum number of citations
9	Citation	**%sc**	Percent self-citations	Disambiguate self-citations from external citations
10	Citation/author	**Fc**	Fractional citation count	Remove dependence of co-authorship, all authors receive equal share of citations.
11	Citation/time	**C<5**	Citations less than 5 years old	Age of citations
Hybrid metrics				
12	Citation/publication/field	**IQP**	Index of Quality & Productivity	Number of citations a scholar's work would receive if it is of average quality in the field
13	Citation/publication/field	**Tc>a**	(part of IQP)	Actual times scholar's core papers are cited more than average quality of field
14	Citation/publication/field	**H norm**	Normalized h	Normalizes h-index (to compare scientists across fields).
15	Citation/publication	**Cage**	Age of citation	If citations are due to recent or past articles
16	Citation/publication	**%PNC**	Percent not cited	If citations are due to a few or many articles
17	Citation/publication	**CPP**	Citations per paper	Average citations per paper
18	Citation/publication	**h**	h index	Cumulative achievement
19	Citation/publication	**g**	g index	Distinction between and order of scientists
20	Citation/publication	**m**	m index	Median citations to publications included in h to reduce impact of highly cited papers
21	Citation/publication	**e**	e index	Supplements h, by calculating impact of articles with excess h citations
22	Citation/publication	**w**	wu index	Impact of researcher's most excellent papers
23	Citation/publication	**hg**	Hg index	Balanced view of production by keeping advantages of h and g, and minimizing their disadvantages
24	Citation/publication	**H^2**	Kosmulski index	Weights most productive papers
25	Citation/publication	**A**	A index	Magnitude of researcher's citations to publications
26	Citation/publication	**R**	R index	Improvement of A-index
27	Citation/publication	**AR**	AR-index	Citation intensity and age of articles in the h core
28	Citation/publication	**ħ**	Miller's h	Overall structure of citations to papers
29	Citation/publication	**Q^2**	Quantitative & Quality index	Relates the number of papers and their impact
30	Citation/publication/author	**hi**	individual h	Number of papers with at least h citations if researcher had worked alone
31	Citation/publication/author	**POP h**	Harzing's publish or perish h index	Accounts for co-authorship effects
32	Citation/publication/author/time	**AWCR**	age weighted citation rate	Number of citations to all publications adjusted for age of each paper
33	Citation/publication/author/time	**AW**	Age weighted h	Square root of AWCR to avoid punishing researcher's with few very highly cited papers. Approximates h index
34	Citation/publication/author/time	**AWCRpa**	Per-author AWCR	Number of citations to all publications adjusted for age of each paper and number of authors
35	Citation/publication /time	**M quotient**	m-quotient	Age weighted h. H divided by years since first publication

36	Citation/publication/time	**Mg**	Mg-quotient	Age weighted g. G divided by years since first publication
37	Citation/publication/time	**PI**	Price Index	Percentage references to documents not older than 5 years at the time of publication of the citing sources
Journal-field benchmarks, calculated by CWTS				
38		**mcs**	Mean citation score	Average citation score
39		**mncs**	Mean normalized citation score.	Shows relation to world average in regards to document type, publishing year and field.
40		**pp top n cites**	Proportion of top papers	Proportion of papers that have received more than 10 citations
41		**pp top prop**	Proportion in top 10% of world	If the article is cited in the top 10% of its field
42		**pp uncited**	Proportion uncited	Proportion uncited papers
43		**mjs mcs**	Crown-type indicator	Average number of citations of the journal the article is published in
44		**mnjs**	Mean normalized journal score	Performance of the journal the article is published in normalized to mncs
45		**mjs pp top n cits**	Crown-type indicator	Proportion of papers that have received more than 10 citations in the publishing journal
46		**mnjs pp top prop**	Crown-type indicator	Proportion of papers in the journal that are in the world pp top %
47		**mjs pp uncited**	Crown type indicator	Percent uncited on average in the publishing journal
48		**prop self cits**	Proportion self-citations	Self citations
49		**int coverage**	Internal coverage.	% cited references in the paper linking to WOS publications since 1980
50		**pp collaboration**	collaboration	Proportion collaboration outside of authors affiliated institution
51		**pp int collab**	International collaboration	Proportion international collaboration
52		**n self cites**	Number of self-citations	Count of self citations

STI 2014 Leiden

Context counts: pathways to master big and little data
Proceedings of the science and technology indicators conference 2014 Leiden

ISBN 978-90-817527-1-8
Cover design by: Ferdy van Gool (KijkMijnHuis B.V.)
Printed by: PP-Offset
Website: ***sti2014.cwts.nl***



STW
Enabling new technology

BRILL

ELSEVIER

THOMSON REUTERS